

CLAIMS

1. Electrostatic actuation device comprising:

- 5 - at least one electrode (10, 33, 35, 37, 135, 137, 139, 210, 335, 337, 339) called the mobile electrode, comprising at least one part free to move with respect to a substrate (22, 123, 222, 322),
- 10 - at least two electrodes (12, 14, 62, 64, 82, 84, 92, 94, 132, 134, 136), fixed with respect to the substrate, located on the same side as the mobile electrode and each facing a part of the mobile electrode,
- 15 - means (18, 28, 98, 158, 198, 398, 399), forming at least one pivot of at least one portion of the mobile electrode, the mobile electrode may bear on the pivot when one of the fixed electrodes attracts the part of the mobile electrode facing which this fixed electrode is located, the other part of the mobile
- 20 electrode possibly moving away from the substrate under the effect of mechanical return forces.

2. Device according to claim 1, the mobile electrode comprising at least one mobile part along at

25 least one direction perpendicular to this substrate.

3. Device according to claim 1 or 2, the two fixed electrodes being separated from the mobile electrode by an insulating layer (20, 120, 220, 224,

30 320) formed on the substrate and/or the mobile electrode.

4. Device according to one of claims 1 to 3, the mobile part of the mobile electrode being connected by a pad (33, 34, 36) to a membrane (30).

5 5. Device according to one of claims 1 to 4, the means forming the pivot comprising at least one pad (18, 98, 158, 198, 398, 399) fixed with respect to the substrate.

10 6. Device according to one of claims 1 to 4, the means forming the pivot comprising at least one arm (28) arranged laterally with respect to the mobile part, or two arms arranged on each side of the mobile part.

15 7. Device according to one of claims 1 to 6, the mobile part of the mobile electrode forming an elbow (77).

20 8. Device according to one of claims 1 to 6, comprising four fixed electrodes (82, 84, 92, 94) arranged in pairs facing each other, the mobile electrode comprising two mobile parts arranged crosswise.

25 9. Device according to claim 8, comprising two pivots (79, 80).

30 10. Device according to one of claims 1 to 9, the mobile electrode comprising at least one part

embedded or fixed on or in the substrate or the insulating layer.

11. Device according to one of claims 1 to 5 10, each fixed electrode being located facing at least one end of the mobile electrode, on one side of the means forming the pivot.

12. Device according to one of claims 1 to 10 6, the mobile electrode comprising at least two mobile parts (135, 137, 139), each part being free at one of its ends, a fixed electrode (132, 134, 136) located facing each mobile part (135, 137, 139).

13. Device according to claim 12, the 15 mobile electrode comprising three mobile parts (135, 137, 139), there being three fixed electrodes (132, 134, 136), each located facing a part of the mobile electrode.

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14. Device according to claim 12 or 13, the mobile parts of the mobile electrode being approximately elongated, and being laterally or angularly offset from each other.

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15. Device according to one of claims 1 - 6, comprising three fixed electrodes, the mobile part comprising three strips (135, 137, 139) connected through an end (140).

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16. Electrostatic actuation device
comprising:

- a part or membrane, called the mobile or flexible membrane with respect to a substrate (22, 123), this part comprising at least two electrodes (13, 15, 135, 137, 139), separated by an electrically insulating portion (11, 141),
- at least one electrode (17, 133), fixed with respect to the substrate, located on the same side of the mobile part and for which a first part and a second part are located facing one of the corresponding electrodes of the mobile part,
- means (18, 28, 98, 158, 198, 398, 399), forming at least one pivot of at least one portion of the mobile or flexible part or membrane that may bear on the pivot when one of the fixed electrodes attracts one of the electrodes of the mobile or flexible part or membrane, the other mobile electrode being free to move away from the substrate under the effect of mechanical return forces.

17. Device according to claim 16, the mobile part being free to move along at least a direction perpendicular to the substrate.

18. Device according to claim 16 or 17, the two fixed electrodes being separated from the mobile electrode by an insulating layer (20, 120, 220, 224, 320) formed on the substrate and/or the mobile electrode.

19. Device according to one of claims 16 to 18, the mobile part being connected by a pad (33, 34, 36) to a membrane (30).

5 20. Device according to one of claims 16 to 19, the means forming the pivot comprising at least one pad (18, 98, 158, 198, 398, 399) fixed with respect to the substrate.

10 21. Device according to one of claims 16 to 20, the means forming the pivot comprising at least one arm (28) arranged laterally with respect to the mobile part, or two arms arranged on each side of the mobile part.

15 22. Device according to one of claims 16 to 21, the mobile part forming an elbow (77).

20 23. Device according to one of claims 16 to 22, comprising four fixed electrodes (82, 84, 92, 94) arranged in pairs facing each other, the mobile part comprising two mobile parts arranged crosswise.

25 24. Device according to claim 23, comprising two pivots (79, 80).

30 25. Device according to one of claims 16 to 25, the mobile part comprising at least one part embedded or fixed on or in the substrate or the insulating layer.

26. Device according to one of claims 16 to 25, each fixed electrode being located facing at least one end of a mobile electrode, on one side of the means forming the pivot.

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27. Device according to one of claims 16 to 21, the mobile part comprising at least two mobile electrodes (135, 137, 139), connected at one end by an insulating portion (141), each mobile electrode being
10 free at one of its ends, a fixed electrode (132, 134, 136) facing each mobile electrode (135, 137, 139).

28. Device according to claim 27, the mobile part comprising three mobile electrodes (135,
15 137, 139).

29. Device according to claim 27 or 28, the mobile electrodes being approximately elongated and being laterally or angularly offset from each other.

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30. Device according to one of claims 16 to 29, comprising at least two fixed electrodes.

31. Device according to one of claims 1 to 25 30, an electrical contact element (196, 350) being fixed on the mobile part.

32. Device according to claim 1 or 16, the mobile electrode, the fixed electrodes and the pivot
30 being approximately in a plane on the surface of the substrate.

33. Device according to one of the previous claims, at least one mobile electrode comprising magnetic or partially magnetic means (232, 234), the device also comprising fixed magnetic means (242, 244,
5 342, 344) with respect to the substrate, that can create a contact with the magnetic means of the mobile electrode.

34. Device according to claim 33, the
10 electrostatic force and the magnetic forces involved during a contact having a relative difference of about 10%.

35. Device according to claim 33 or 34, the
15 electrostatic force(s) and the magnetic force(s) involved during a contact being greater than the mechanical return forces.

36. Device according to claim 35, the
20 electrostatic force and the magnetic forces involved during a contact being at least 10 times greater than the mechanical return forces.

37. Device according to one of claims 33 to
25 36, the magnetic means of the mobile electrode and the fixed magnetic means defining at least two stable positions of the device.

38. Device according to one of claims 1 to
30 37, also comprising at least one fixed electrode and one mobile electrode defining a capacitor.

39. Device according to one of claims 1 to 38, the means forming the pivot being used to hold a point of a mobile electrode at a height of between 50 nm and 20µm with respect to the substrate.

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40. Actuation device for an optical component comprising:

- at least one electrostatic actuation device according to one of claims 1 to 39,
- 10 - support means (610, 617) for an optical component, connected to the membrane or to the mobile electrode of the actuation device, and being driven in displacement by this membrane or this electrode during displacement of this membrane or this electrode.

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41. Device according to claim 40, at least one of the electrodes of one of the actuation devices comprising an elongated body (621.1) with a first width along a first direction and an end (621.3) called the starter with a second width wider than the said first width.

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42. Device according to one of claims 40 or 41, comprising two electrostatic actuation devices according to one of claims 1 to 39, the support means (610, 617) of an optical component being connected to these two devices.

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43. Device according to claim 42, the two actuation devices being arranged on each side of the support means of an optical component.

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44. Device according to claim 42, the two actuation devices being arranged on the same side as the support means of an optical component.

5 45. Device according to one of claims 42 to 44, the two actuation devices extending along two directions approximately parallel to each other.

 46. Device according to one of claims 42 to
10 44, the two actuation devices each comprising a curved part.

 47. Device according to claim 46, the two actuation devices being mechanically connected by at
15 least one common end (621.3).

 48. Device according to one of claims 42 to 47, comprising two drive arms (623) connecting the two electrostatic actuation devices to the support means
20 (610, 617) of an optical component.

 49. Device according to one of claims 42 to 48, comprising a substrate in which a cavity (626) enables pivoting of support means of the optical
25 component.

 50. Device according to one of claims 42 to 49, also comprising a frame (615) and connecting means (613) connecting the electrostatic actuation device and
30 the support means (610, 617) of an optical component to the frame.

51. Device according to claim 50, the connecting means (613) comprising torsion arms (613).

5 52. Device according to claim 42, the support means (800) having a closed contour with a curvature.

53. Device according to claim 52, the electrostatic actuation means being arranged around or
10 along the said contour.

54. Device according to claim 52, the electrostatic actuation means being arranged radially with respect to the said contour.

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55. Device according to one of claims 52 to 54, the contour being circular.

56. Device according to one of claims 52 to
20 55, also comprising stretching means (804) arranged between the electrostatic actuation means and the support means (800).

57. Device according to claim 56, the
25 stretching means (804) comprising at least one stretching loop.

58. Manufacturing process for a device according to one of claims 1 to 39, comprising:

- creation of a first substrate, comprising one or two fixed electrodes with respect to the substrate,

5 - manufacture of means (630) forming the pivot and a mobile electrode or membrane, comprising at least two electrodes separated by an insulating portion, this electrode or this membrane being free to move with respect to the substrate.

10 59. Process according to claim 58, the mobile electrode or membrane being made on a sacrificial layer (532) formed or deposited on the substrate, and then eliminated after formation of the mobile membrane or electrode.

15 60. Process according to claim 58, the mobile electrode or membrane being made on the surface of a second substrate (1000) then assembled with the first (1200).

20 61. Process according to claim 59, the mobile electrode or membrane then being removed from the surface of the second substrate by thinning the second substrate.

25 62. Process according to one of claims 58 to 61, the means forming the pivot being formed on the first substrate.